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Investigating the Diurnal Cycle of Summer Precipitation over Mainland Southeast Asia: Insights from Dynamic downscaling Simulations

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The precipitation changes over mainland Southeast Asia (SEA) are important to water resources in many countries in this region. The diurnal cycle of precipitation is a crucial aspect of the local climate. The sub-daily convective activities and precipitation variability are strongly modulated by the surrounding complex topography However, the intricate interplay between topographical features and local atmospheric processes, and how they shape the spatial distribution of diurnal precipitation variability across SEA, remains unclear. This study investigates diurnal precipitation patterns and associated physical processes, particularly focusing on modeling the diurnal cycles in this region using convection-permitting models (CPMs). To investigate the effect of model resolution on diurnal precipitation and associated processes, we conducted two high-resolution simulations using the Weather Research and Forecasting (WRF) model driven by ERA5 at spatial resolutions of 9 and 3 km, focusing on summertime (June-August) during 2002-2005. We compared the output from the two WRF experiments to ERA5 and observation-based datasets, including in situ observations (GHCN-D), and gridded observations (APHRODITE, IMERG). The diurnal patterns in space were clustered into 5 distinct groups based on K-means classification. Compared with the ERA5 reanalysis, the two high-resolution WRF simulations show a reduced wet bias relative to IMERGE and better captured intense precipitation events found in the in situ measurements, while the precipitation in ERA5 is more similar to APHRODITE. Furthermore, the results show that the WRF simulations outperform ERA5 in capturing the spatial patterns of precipitation intensities and peak time, especially in mountainous and coastline regions, using IMERG as the reference. These differences can be explained by differences in convective available potential energy (CAPE) between the WRF simulations and ERA5, as well as near-surface winds. Between the two WRF simulations, the 3-km WRF simulation displays weaker precipitation intensities compared to the 9-km WRF simulations, which better match the hourly IMERG data, while the 9-km WRF simulations perform better in peak time of diurnal precipitation. Assessing the benefits of higher-resolution modeling is challenging because the benefits vary between variables and regions. In conclusion, the work highlights the importance of applying CPMs to capture diurnal cycles of precipitation, local convective activities (CAPE), and near-surface winds over complex topography.